

A Comparison of Macroinvertebrates Collected from Bottom Sediments in Three Lake Erie Estuaries

Philip A. Lewis
Bioassessment and Ecotoxicology Branch
Environmental Monitoring Systems Laboratory
U.S. Environmental Protection Agency
3411 Church Street, Cincinnati, Ohio 45244

Mark E. Smith
Technology Applications Inc.,
C/O U.S. Environmental Protection Agency,
3411 Church Street, Cincinnati, Ohio 45244

Abstract

Macroinvertebrates were collected from bottom sediments from three Lake Erie tributaries as a part of EMSL's Biomarker Project. The objective of this paper is to compare the macroinvertebrate populations collected from the three water bodies and relate these populations to possible pollutional stresses and/or habitat characteristics. Three grab samples were collected with either a petite Ponar or a standard Ekman-on-a-stick at three different stations at each site. The sampling stations were chosen randomly from among the nine stations used for collecting fish at each site. In the Black River above a Coking Plant, 60-80% of the organisms were tolerant oligochaete worms but some pollution sensitive organisms were also present indicating organic enrichment but not toxic pollution. All of the individuals collected from below the plant were oligochaete worms (90%) and other organisms tolerant of both organic and toxic pollution. In Old Woman Creek, over 80% of the individuals collected were oligochaete worms and blood worms (midges) characteristic of organically enriched sediments associated with high oxygen demand. Toussaint Creek samples were characterized by a variety of midge larvae and many empty mollusk shells but few live mollusks. Less than 50% of the individuals were oligochaete worms. This may be a reflection of the sediment characteristics which consisted of gravel and clay with little of the muck substrate characteristic of the other two sites. The data indicate that all three sites are effected by organic enrichment and/or agricultural runoff, but the Black River macroinvertebrate community below the Coking Plant appears to be stressed by something in addition to organic enrichment.

Key Words: macroinvertebrates, bottom sediments, pollution, water quality, organic enrichment, biotic index.

Introduction

As part of EMSL-Cincinnati's Biomarkers Research Program, fish and macroinvertebrates were collected from the Black River, Old Woman Creek and Toussaint Creek during April 23-25, 1990. The project objective is to determine if biomarkers can be used to detect a wide range of pollutants. The Black River site was chosen as one study site because of polycyclic aromatic hydrocarbons that have been detected in the sediment downstream from a coking plant and the resulting high incidence of liver cancer in brown bullhead that inhabit the

site. Old Woman Creek and Toussaint Creek were sampled as possible control sites.

The purpose of this paper is to compare the macroinvertebrate populations collected from the three water bodies and attempt to relate these populations to pollutional stresses and/or habitat characteristics.

Methods

Nine fyke fish nets were set at each site along both east and west banks over a distance of approximately one mile. Each net was defined

as a sampling station for fish. Three of these stations were randomly chosen as benthic macroinvertebrate collection stations on each water body. Three six inch Ekman or Ponar grab samples were collected at each station and preserved in 70% ethanol. The samples were returned to the laboratory, sorted and the organisms identified to the lowest taxonomic level possible. Pollution tolerance value for each taxa were taken from EMSL-Cincinnati's Biological Methods Manual (USEPA 1990) or Hilsenhoff (1987). Sediment and water samples were also collected at each station for chemical analysis.

Stations were analyzed using Hilsenhoff's (1977) modification (HBI) of Chutter's (1972) Imperial Biotic Index, Shannon-Weaver's mean diversity (d), and equitability (e). Although the HBI was designed to give a measure of the effects of organic pollution on the macroinvertebrate communities inhabiting stream riffles, it should be useful in analyzing grab samples collected from soft river substrates if care is used in interpreting the data. An HBI score of <1.75 would indicate excellent water quality, 1.76 - 2.50 good water quality, 2.51 - 3.75 fair water quality, 3.76 - 4.00 poor water quality, and >4.00 would indicate grossly polluted conditions. Mean diversity values of less than 1.0 are characteristic of gross pollution, values between 1.0 and 3.0 indicate fair to poor water quality, and values above 3.0 are common for clean water stations.

Equitability values above 0.5 are indicative of good water quality, 0.3 - 0.5 fair, and values below 0.3 indicate degradation of water quality. Stations within each site and the three water bodies (between sites) were compared using the Community Loss Index and Jaccard's Coefficient of Similarity (Plafkin et al. 1989). Trophic condition index (Howmiller and Scott 1977; Milbrink 1983) was also determined for each station but the results were not helpful in interpreting the data, possibly because most of the oligochaete worms could not be identified to species.

Station descriptions

Old Woman Creek - Station 1 was located 200 feet north of the RR bridge about 25 feet from the west shore. Substrate was muck and well rotted organic material; water depth was about 18 inches. Station 2 was located 100 feet west of the observation deck about 50 feet from shore. Substrate was muck with some clay; water depth was about 18 inches. Station 3 was located 500 feet south of the Highway 2 bridge and about 150 feet west of a high gravel bank near the east shore of the estuary. Substrate was muck and rotting leaves; water depth was about 16 inches.

Toussaint Creek - Station 1 was located 200 feet north of Highway 2 bridge about 50 feet from the east shore. Water depth was about six feet and the substrate was sandy and silty. Station 2 was located about one half mile south of Highway 2 bridge about 50 feet from the east shore just south of a small island. Water depth was about two feet and substrate was hard packed gravel with some clay and silt. Station 3 was located across the bay from Station 2 about 50 feet east of a very small island. Water depth was about three feet and substrate was muck, clay and hard packed gravel. A large ditch entered the bay about 50 feet north of the station.

Black River - Station 1 was located about four miles upstream from the mouth of the river about 30 feet from the west bank across from, and about 100 feet upstream from, the upper end of a large island. Water depth was about seven feet and the sediment was mostly fine silt. Station 2 was located about 100 feet downstream from the lower end of the large island about 20 feet from the bank. Water depth was about two feet and the sediment was muck, clay and leaves. Station 3 was about one half mile downstream from a major discharge from the coking plant at the bend of the river about 20 feet from the west bank at about river mile three. Water depth was 2 1/2 feet and the sediment was mud and silt.

Results and Discussion

Toussaint Creek. The Ponar samples collected at Station 1 (Table 1) yielded 13 taxa, two of which (see below) are not generally found in polluted waters and six of which are highly tolerant of organic pollution. Just over half (56%) of the individuals were oligochaete worms which is an indication of non-polluted conditions (Goodnight and Whitley 1960). The HBI of 3.76, the diversity index (2.3) and equitability (0.5) all indicate fair to marginal water quality. The large number of empty mollusk shells (123 individuals representing 8 species) indicate that conditions have been present, at least some time recently, for a diverse population of these organisms to develop. The midge larvae Ablabesmyia mallochii, which is very sensitive to metals contamination, and the gastropod Somatogyrus, which is not generally found in organically polluted waters indicate that this station is probably not, or only slightly, impaired by pollutants. Probably this is the least impacted station sampled during this study; therefore it was used as the reference station for this study.

The three Ekman samples collected at Station 2 (Table 1) contained only five living taxa, consisting of the midge Polypedilum scalaenum, which is generally restricted to unimpaired waters, two pollution tolerant oligochaete worms, and two facultative (wide range of tolerance) midge species. Less than half the individuals (36%) collected were oligochaete worms which indicates non impaired conditions (Goodnight and Whitley, 1960). The HBI of 3.33, the diversity index (1.8) and equitability (1.0) all indicate fair to good water quality conditions at this station. The presence of the midge Polypedilum scalaenum also indicates that toxic substances are probably not present in concentrations high enough to effect the biological integrity of the aquatic community. The lack of a diverse fauna is probably due to the difficulty of obtaining a sample because of the hard packed gravel and clay substrate. The Ekman sampler used was one with a handle so

that it could be pushed with some force into the bottom or the samples could not have been taken here.

The three Ponar samples taken at Station 3 (Table 1) contained only seven living taxa but 14 taxa of empty mollusk shells. It seems odd that so many shells were collected without any live animals. Perhaps something had recently occurred that killed all the mollusks, but it is obvious that conditions in the recent past must have been conducive to the establishment of a diverse population. Only two taxa present (the midge Cryptochironomus sp. and the oligochaete worm Limnodrilus hoffmeisteri) are tolerant of pollution, however, these two taxa make up about 80% of the individuals collected. This station was very near a ditch that enters the bay here and it is possible that periodically toxic and/or organic substances may flow into the bay from this ditch causing stress on the benthic community. Our sampling may have occurred during the beginning of the recovery period. The samples were collected in the spring soon after planting and storm runoff from nearby agricultural lands may have entered the bay by way of this ditch. Krieger (1989) reported that agricultural herbicides used with corn and soybeans reach higher concentrations in rivers of northwest Ohio than in rivers anywhere else in North America. The Biotic Index of 3.73 indicates only a slight impact as do the diversity index (1.5) and equitability (0.5). The high percentage of oligochaete worms at this station as compared to the other two may be an indication that whatever has effected the benthic community was not limiting to the oligochaete worms and probably was not widespread throughout the bay.

Community Loss Index and Jaccard's Coefficient of Similarity indicate that the three stations are quite dissimilar with the greatest difference between stations 1 and 2. If station 1 is considered the control, station 2 shows a loss of 2.2 and station 3 shows a loss of 1.4. These differences would appear to be significant and one might expect that stations 2 and

Table 1. Macroinvertebrates Collected and Pollution Tolerance Values for Toussaint Creek. Intolerant taxa denoted by *.

Taxa	Number of Individuals			Pollution Tolerance Value
	Station 1	Station 2	Station 3	
Chironomidae				
Coelotanytus concinnus	11			4
Cryptochironomus sp.			1	4
Cryptochironomus fulvus gr.	4		2	3
Procladius nr. bellus	30	5	2	3
Chironomus plumosus gr.	1			5
Ablabesmyia mallochi *	1			2
Cladotanytarsus sp.		15	2	3
Polypedilum scalaenum *		1	1	2
Tanytarsus guerlus gr.			1	3
Other Diptera				
Ceratopogonidae				
Nr. Probezzia sp.	2			3
Crustacea				
Isopoda				
Lirceus lineatus	2			3
Bryozoa				
Urnatella gracilis	P			3
Bivalvia				
Sphaeriidae	3			4
Gastropoda				
Somatogyrus sp. *	1			2
Oligochaeta				
Limnodrilus hoffmeisteri	7		1	5
L. maumeensis	1			5
Branchiura sowerbyi	1	2		4
Unidentified Oligochaeta	62	10	31	4
Total Individuals	126	33	41	
Total Taxa	13	5	7	
% Oligochaeta	56	36	78	
Biotic Index (HBI)	3.76	3.33	3.73	
Mean Diversity (d)	2.3	1.8	1.5	
Equitability (e)	0.5	1.0	0.5	

3 would be quite similar because the Community Loss Index between them is small, but Jaccard's Coefficient (<0.50) indicates otherwise. HBI scores for stations 1 and 2 and for 2 and 3 are statistically different from each

other but HBI scores for stations 1 and 3 are similar. Probably most of the differences observed are ecological and not caused by pollution.

The data suggest that Toussaint Creek Bay is not affected to any great extent by pollution, however, the presence of many species of empty mollusk shells at stations 1 and 3 leads me to suspect that occasional instances may occur, either natural or man caused, that stress the aquatic community and temporarily affect the biological integrity of the bay in the vicinity of the canal that enters the bay on the west shore. Runoff from agricultural lands during storms may be a factor here as in most other northwest Ohio rivers (Krieger 1989). A total of 17 taxa consisting of 200 individuals (11.8/taxa) were collected in the nine grab samples taken from Toussaint Creek.

Old Woman Creek. The three Ekman samples collected at Station 1 (Table 2) yielded nine taxa, including the bryozoan Pectinatella magnifica which is known to be sensitive to toxic contaminants and five taxa which are highly tolerant to organic pollution. Of the 96 individuals collected 83 (86%) were oligochaete worms characteristic of organically enriched sediments. The HBI of 4.01 and the high percentage of oligochaete worms (Goodnight and Whitley 1960) indicate organic enrichment but the diversity index (2.3) and equitability (0.7) indicate fair to good water quality. The presence of the bryozoan Pectinatella magnifica at this station would indicate good water quality.

The three Ekman samples collected at Station 2 (Table 2) yielded ten taxa, none of which are known to be sensitive to pollution and seven which are highly tolerant of organic pollution. Of the 132 individuals collected, 107 (81%) were oligochaete worms characteristic of organically enriched sediment. The blood worm Chironomus plumosus, which is highly tolerant of sediments with high oxygen demand, was also common at this station. The HBI of 4.03 and the high percentage of oligochaete worms indicate organic enrichment but the diversity index (1.6) and equitability (0.4) would indicate fair water quality.

The three Ekman samples collected at Station 3 (Table 2) contained seven taxa, including the amphipod Gammarus pseudolimnaeus which is generally not found in waters containing toxic substances other than organic enrichment and four of which are highly tolerant to organic pollution. Of the 31 individuals collected, 23 (74%) were oligochaete worms characteristic of organically enriched sediments. The HBI of 3.84 and the presence of Gammarus pseudolimnaeus would indicate that toxic substances are probably not major limiting factors at this station. The percentage of oligochaete worms was less at this station than the other two and fell in the moderately polluted category of Goodnight and Whitley (1960). The diversity index (1.8) and equitability (0.6) indicate fair to good water quality.

Community Loss Index and Jaccard's Coefficient of Similarity show that stations 1 and 2 are quite similar and that station 3 is significantly different from the other two stations. The Community Loss Index values also indicate that station 3 has fewer taxa in common with either of the other two stations. HBI score for station 3 was also lower than for the other two stations, but the difference was not significant ($P=0.05$). However, HBI for Old Woman Creek stations 1 and 2 were significantly higher than for the reference station while station 3 was not significantly different ($P=0.05$).

The data suggest that Old Woman Creek Estuary may have been temporarily affected by storm runoff from agricultural lands (Klarer and Millie, 1989) and organic enrichment from decaying vegetation and that station 3 is slightly less effected than the other two. The limiting factor at this site would most likely be the highly enriched substrate consisting of muck and decaying vegetation probably accompanied by periods of low DO and high levels of nitrites resulting from storm runoff from nearby agricultural lands (Klarer and Millie, 1989). Using Goodnight and Whitley's (1960)

Table 2. Macroinvertebrates Collected and Pollution Tolerance Values for Old Woman Creek.

Taxa	Station 1	Number of Individuals Station 2	Station 3	Pollution Tolerance Value
Chironomidae				
Coelotanytus concinnus	4	6		4
Cryptochironomus fulvus gr	1	1		3
Procladius nr bellus	4	2	5	3
Chironomus plumosus gr	1	9		5
Dicrotendipes sp.	1			4
Other Diptera				
Ceratopogonidae				
Nr Probezzia sp.	2	7		3
Coleoptera				
Dubiraphia sp	1			3
Coleoptera				
Donacia sp.			1	3
Cruatacea				
Gammarus pseudolimnaeus *			1	2
Oligochaeta				
Limnodrilus maumeensis	2	2	1	5
L. hoffmeisteri	5	3	2	5
L. cervix		2	1	4
Branchiura sowerbyi		2		4
Ilyodrilus templetoni		1		4
Unidentified Oligochaeta	76	97	19	4
Bryozoa				
Pectinatella magnifica *	P	S	S	1
Total Individuals	96	132	31	
Total Taxa	9	10	7	
% Oligochaeta	86	81	74	
Biotic Index (HBI)	4.01	4.03	3.84	
Mean Diversity (d)	2.3	1.6	1.8	
Equitability (e)	0.7	0.4	0.6	

metric based on percent oligochaete worms present, all three stations would be considered polluted. A total of 15 taxa consisting of 259 individuals (17.3/taxa) were collected in the nine grabs taken from Old Woman Creek.

Black River. The three Ponar samples collected at Station 1 (Table 3) contained 18 taxa most of which are characteristic of slightly impaired

or organically polluted waters. Two midge species, Dicrotendipes neomodestus and Harnischia curtilamellata, present at this station are usually not found under contaminated conditions. Of the 137 individuals collected 106 (77%) were oligochaete worms which would indicate moderately polluted or organically enriched sediments. The HBI of 3.92, the diversity index (2.4) and equitability (0.4) all

Comparison of Macroinvertebrates in Lake Erie Estuaries

Table 3. Macroinvertebrates Collected and Pollution Tolerance Values for Black River.

Taxa	Number of Individuals			Pollution Tolerance Value
	Station 1	Station 2	Station 3	
Chironomidae				
Harnischia curtilamellata *	1			2
Ablabesmyia mallochi *		3		2
Tanytarsus guerlus gr		2		3
Phaenopsectra prob dyari		2		3
Eukiefferiella claripennis		2		4
Hydrobaenus pilipes gr *		1		2
Cryptochironomus fulvus gr	7	1	11	3
Cryptochironomus sp	1	1	1	4
Diplocladius cultriger	1			4
Dicrotendipes neomodestus	1	2		2
Polypedilum ophioides	1			3
Glyptotendipes lobiferus	1	2	1	3
Orthocladius sp.			1	3
Cricotopus tremulus gr		2		3
Corichapelia sp.			1	3
Procladius nr. bellus		1	9	3
Nanocladius distinctus		1		3
Other Diptera				
Hemerodromia sp	2	3		3
Chaoborus punctipennis	10	1	1	3
Nr. Probezzia sp.	3			3
Ephydriidae	1			3
Unidentified Diptera		1		3
Coleoptera				
Elmidae				
Stenelmis sp. *		21		2
Dubiraphia sp.		4		3
Staphylinidae		1		2
Helodidae				
Scirtes sp		1		3
Noteridae				
Berosus sp		1		3
Ephemeroptera				
Caenis sp	2	2		3
Lepidoptera				
Bactra sp (?)		1		2
Hydracarina				
Trombidiformes		1		2
Odonata				
Argia apicalis		1		3

Table 3. Macroinvertebrates Collected and Pollution Tolerance Values for Black River.
(Continued)

Taxa	Number of Individuals			Pollution Tolerance Value
	Station 1	Station 2	Station 3	
Crustacea				
Isopoda				
<i>Asellus communis</i>		6		3
Bivalvia				
<i>Pisidium casertanum</i>		1	1	4
Gastropoda				
<i>Physella vinosa</i>			1	4
Bryozoa				
<i>Lophopodella carteri</i> *		P		1
Oligochaeta				
<i>Limnodrilus hoffmeisteri</i>	17	23	24	5
<i>L. udekemianus</i>		5	1	5
<i>L. cervix</i>	7	6	4	4
<i>Potamothenis vejdoskyi</i> *		2		3
<i>Tubifex tubifex</i>		2		5
<i>Ilyodrilus templetoni</i>		2		4
<i>Quistadrilus multisetosus</i>	1	3	1	4
<i>Dero</i> sp.	1			5
<i>Nais elinguis</i>	1			4
<i>Nais communis</i>		1		4
Enchytraeidae	1			4
Unidentified Oligochaeta	78	55	172	4
Total Individuals	137	164	229	
Total Taxa	18	35	13	
% Oligochaeta	77	60	88	
Biotic Index	3.92	3.62	4.00	
Mean Diversity (d)	2.4	3.7	1.5	
Equitability (e)	0.4	0.5	0.3	

* Intolerant taxa

indicate fair to poor water quality at this station which is located upstream from the major effluent from the coking plant. The mayfly Caenis sp., present at this station, is the most tolerant of the mayflies and is not a good water quality indicator.

The three Ponar samples collected at Station 2 (Table 3) yielded a surprising 35 taxa, many of which would not be expected in mud substrate where little current is present. Nine of the taxa are tolerant of pollution, one (Lophopodella carteri) is very sensitive to pollution (except in the statoblast stage) and seven others are not characteristically found in impaired waters. Almost exactly 60% of the individuals are oligochaete worms characteristic of organically polluted conditions which would indicate some organic enrichment, possibly due to decaying vegetation. It is not likely that toxic pollution is present in the sediment at this station because Potamothrix vejdovskyi, an intolerant oligochaete, was among the diverse worm fauna present. The diversity of midge and other insect groups would indicate that conditions are conducive to the development of a balanced benthic community. This may be due, however, to the possibility that these organisms are drifting into this station from some stream that may enter the river behind the island just upstream or from a spring entering the river from under the stream bank. The HBI of 3.62, diversity index (3.7) and equitability (0.5) all indicate fair to good water quality.

The three Ponar samples collected at Station 3 (Table 3) contained 13 taxa, eight of which are characteristic of polluted conditions. The other five species are all facultative and could be present in moderately polluted waters. Of the 229 individuals present, 202 (88%) were oligochaete worms indicating grossly polluted waters. It is interesting that the only deformed Procladius midge (Warwick, 1989) found during this study was collected from this station which is located one half mile downstream of the main effluent from the coking plant. The HBI of 4.00 indicates poor water quality as does the

equitability (0.3) while the diversity index (1.5) is borderline between fair and poor conditions.

Community Loss Index and Jaccard's Coefficient of Similarity show that the three stations are considerably different from one another. Both stations 1 and 3 show significant community loss when compared with station 2. The HBI scores for the three stations are similar ($P = 0.05$), however the HBI scores for stations 1 and 3 are both significantly higher than for the control reference station.

The data suggest that the benthic community at Station 1, located upstream from most of the effects of the coking plant, does show some stress on the biota. Station 2 samples contain intolerant organisms (including riffle beetles) which are not characteristic of muddy substrates and some tolerant forms that are characteristic of organic pollution. Station 3 is noticeably degraded as compared to the other stations sampled during this study. A total of 47 taxa consisting of 530 individuals (7.2/taxa) were collected in the nine grab samples taken from the Black River.

Summary and Conclusions

The Community Loss Index and Jaccard's Coefficient of Similarity show that Old Woman Creek and Toussaint Creek macroinvertebrate communities are more similar to each other than either one is to the Black River but these similarities are not very great. There is no significant community loss between Old Woman Creek or Toussaint Creek and the Black River when composite data are compared. Based on the Community Loss Index, it would appear that Old Woman Creek and Toussaint Creek are both slightly less polluted than the Black River, but this is likely due to the diverse fauna collected from Black River station 2 as discussed above.

Toussaint Creek station 1 is considered the best control station because of its representative substrate and overall quality based on the combination of metrics used in

this analysis. Using this as the reference station, Community Loss, Jaccard's Coefficient of Similarity and t-values based on a comparison of HBI scores for the other stations sampled are as follows:

Community					
Stations Compared	Loss Index	Jaccard's Coeff.	HBI t-values		
Toussaint 2	2.2	0.13	2.597	*	
Toussaint 3	1.4	0.19	0.040	ns	
Old Woman 1	0.3	0.44	4.590	*	
Old Woman 2	0.6	0.47	4.531	*	
Old Woman 3	1.6	0.13	0.241	ns	
Black River 1	0.6	0.11	2.531	*	
Black River 2	0.2	0.12	0.146	ns	
Black River 3	0.7	0.18	3.983	*	
Old Woman Creek Composite	0.4	0.37	3.073	*	
Black River Composite	0.1	0.10	1.108	ns	

*Significant at $p < 0.05$, $df = 4$.

These metrics indicate that Toussaint Creek stations 2 and 3, Old Woman Creek Stations 1, 2, and 3 and Black River stations 1 and 3 are different from the reference station. The differences between the Toussaint Creek stations can be explained by substrate differences but the others could be related to pollution, including agricultural runoff (Krieger 1989). As might be expected Black River station 2 did not show a community loss (see discussion of the individual stations above). Based on Jaccard's Coefficient all the stations are significantly different from the reference station and all but Old Woman Creek stations 1 and 2 are vastly different. All of the HBI scores differ significantly ($P = 0.05$) from the reference station except Toussaint Creek station 3, Old Woman Creek station 3, Black River station 2, and the Black River composite. The reason the Black River composite HBI scores did not differ from the reference station is probably because of the high variability due to station 2 Black River samples. As mentioned above, the dissimilarities between the reference station and stations 2 and 3 at Toussaint Creek and

Black River station 2 may be attributable to environmental and/or physical factors. The other dissimilarities could be due to organic or toxic stresses. The Community Loss Index and Jaccard's Coefficient scores for the composite data indicate that Old Woman Creek is more like the reference station than is the Black River. The low Community Loss Index score and the low t-value for the composite Black River samples as compared to the reference station are mostly due to the diverse fauna collected at station 2 as discussed above.

Because the sediment samples that were collected for chemical characterization have not yet been analyzed, it is impossible to reach any real definitive conclusions based on the macroinvertebrate collections alone. However, the benthic macroinvertebrate grab collections seem to indicate that all three Old Woman Creek stations were organically enriched, with oligochaete worms making up over 60% of the individuals and the remaining taxa characteristic of waters with high oxygen demand. In Toussaint Creek only Station 3 located near a drainage ditch showed signs of stress. That may be due to periodic discharge of toxic and/or organic pollutants into the bay from this ditch, possibly during storms. Oligochaete worms made up 60% or more of the individuals collected from the Black River at all three Stations indicating organic enrichment or toxic substances in the sediment (Krieger 1990). However, a few sensitive taxa were found at Stations 1 and 2 indicating reasonably good water quality at these two stations. Station 3 samples contained about 90% worms and no sensitive taxa indicating a stressed community of benthic macroinvertebrates.

The complete absence of Hexagenia mayflies, the limited number of chironomids and gastropods, and the increase in oligochaetes in Lake Erie bays has been correlated with increased pollution in the lake (Edwards 1990, Reynoldson et al. 1989). Because no Hexagenia mayflies and only a few live gastropods were collected at any of the sites sampled during this

study, it might be reasonable to assume that all of the sites were polluted.

Neither Old Woman Creek or Toussaint Creek appear to be good control sites. Grab samples collected from the Grand and Chagrin Rivers will be analyzed and the data compared with the Black and Cuyahoga Rivers to determine if either of them might be better control sites for the benthic phase of this study.

Acknowledgments

We would like to thank Larry Linns, Eastern District Office, U.S. EPA Region 5 for providing a boat and assisting with collection of the samples. This work was a part of Susan Cormier and Tim Neiheisel's Biomarker Research Project.

Literature Cited

Chutter, F.M. 1972. An empirical biotic index of the quality of water in South Africa streams and rivers. *Water Research* 6:19-30.

Edwards, C.J. 1990. Biological surrogates of mesotrophic ecosystem health in the Laurentian Great Lakes. Great Lakes Science Advisory Board, Windsor, Ontario.

Hilsenhoff, W.L. 1977. Use of arthropods to evaluate water quality of streams. Technical Bulletin 100, Department of Natural Resources, Madison, WI.

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. *Great Lakes Entomologist*. 20:31-39.

Howmiller, R.P. and M.A. Scott. 1977. An environmental index based on relative abundance of oligochaete species. *Journal of the Water Pollution Control Federation* 49(5):809-815.

Goodnight, C.J. and L.S. Whitley. 1960. Oligochaetes as indicators of pollution. *Proceedings of the 15th Industrial Waste Conference, Purdue University Engineering Bull.*

100:139-149.

Klarer, D.M. and D.F. Millie. 1989. Amelioration of storm-water quality by a freshwater estuary. *Archives of Hydrobiology* 116(3):375-389.

Krieger, K.A. 1989. Chemical limnology and contaminants. Pages 149-175 in K.A. Krieger (editor). *Lake Erie estuarine systems: Issues, resources, status and management*. Estuary of the Month Seminar Series No. 14, NOAA Estuarine Programs Office.

Krieger, K.A. 1990. Assessing lake quality improvement using trends in benthic macroinvertebrate communities: A case study in Lake Erie. Presented at the 1990 Midwest Pollution Control Biologists Meeting, Chicago, Illinois.

Milbrink, G. 1983. An improved index on the relative abundance of oligochaete species. *Hydrobiologia* 102:89-97.

Plafkin, J.L.; M.T. Barbour; K.D. Porter, S.K. Gross and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. 20460. EPA/440/4-89/001.

Reynoldson, T.B.; D.W. Schloesser and B.A. Manny. 1989. Development of a benthic invertebrate objective for mesotrophic Great Lakes waters. *Journal of Great Lakes Research* 15(4):669-686.

USEPA. 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. U.S. Environmental Protection Agency, Environmental Monitoring System Laboratory, Office of Research and Development, Cincinnati, OH 45268. EPA/600/4090/030

Warwick, W.F. 1989. Morphological deformities in larvae of Procladius Skuse (Diptera: Chironomidae) and their biomonitoring potential. Canadian Journal of Fisheries and Aquatic Sciences 46(7):1255-1271,